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METALLIC POWDER PROCESSING FOR OBTAINING HOLLOW ELECTRODES WITH COMPOSITE STRUCTURE

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Depunerile termice ale electrodului tubular cu structură compozită, pe diferite suprafeţe metalice, duc la realizarea unor straturi cu proprietăţi controlate în domeniul rezistenţei la uzură de abraziune. Sunt prezentate cercetările şi experimentările efectuate pentru realizarea de noi tipuri de materiale pentru încărcare şi anume: electrozi tubulari cu structură compozită, destinaţi protecţiei la uzură de abraziune şi impact puternic.

Thermal spraying coatings obtained by using hollow electrode with composite structure, on different metallic surfaces, lead to obtaining of layers with good behavior in abrasive resistance, and coatings with structural properties. The paper presents the experiments performed in order to produce hollow electrodes with composite structure, for protection to abrasive resistance and severe mechanical shocks.

Keywords*:* thermal spraying coating, hollow electrode, composite structure.

1. Introduction

By using thermal coating technologies important economies may be obtained regarding raw materials and stocks, prolonging the lifetime and decreasing the frequency of planned outages. As a result of thermal coating process layers are obtained with special properties or layers that have improved qualities and characteristics as that of the sub-layer.

Due to the efforts diversity at which the parts are exposed during the usage it would be comfortable to have only a single material able to resist to all types of wears, but the complexity of work condition together with economic consideration lead to the expansion of a great number of powder materials which are used in thermal spraying technologies [1].

The main used criteria to chose a material for a certain application are linked by the compatibility with the base metal which must be covered, the assembly behavior of covered layer-sub-layer during wear process and not at least the thermal coating operation cost.

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The main advantages of the hollow electrodes derive from their constructive concept: core wire from steel strip filled with powder core, which contain alloying elements and graphite layer, or basic graphitic layer, thin, applied by immersion [2].

The most important advantages of the hollow electrodes compared with conventional electrodes are the following:

- Processing technology much simpler and much less expensive;
- The welding/charging currents reduced by ~ 1/3;
- Reduced distortion of the charged parts;
- Deposition of thin layers is possible;
- Doesn't produce penetrate burnings in thin parts;
- Reduced slag ;
- Much higher covering efficiency;
- Reduced losses in processing and usage.

3. Experimental conditions

The processing powder experiments from the FeCrSiNiMnC system were obtained by an atomization device of the metallic melt with water at high pressure, thus:

1. the raw materials have been chemically analysed and then comminuted to the desired sizes for their introduction in the induction furnace;
2. metallic nickel was crushed by means of crocodile semiautomatic shears, and the master alloys FeCrSi and NiCrSi, being brittle, have been crushed by means of a hydraulic press.

The raw material melting and the alloy obtaining had been realized with an induction furnace ICI 10/8000 type .[3]

During the melting process the following parameters were taken into consideration:

- excitation current value: 2.5 – 4.0 A;
- mean frequency tension voltage value: max. 750 V;
- mean frequency current value: max.150 A;
- melting power: 50 kW;
- melting time for a 6 kg charge: 35 min.

The next step in the flow-sheet was mixing. The powder mixing consisted of a humid homogenization process which is done for the coating powder mixing, for slurry obtaining for immersion, using a propeller mixer, after the powder components were subjected to dry homogenization. During mixing a binder was added, which was liquid sodium silicate, till we obtained slurry with a viscosity between 150 – 200 cp. Distilled water was added in order to obtain an optimum viscosity for the slurry. The mixing time was between 10 to 15 min, considering the binder characteristics and the work temperature, which is recommended to be 18 – 20 ^{0}C.

3. Results and discussions

By using the above-mentioned flow-sheet, three types of powders have been selected for obtaining hollow electrodes, whose chemical composition are presented in Table 1.

Table 1

Chemical composition of powders used for obtaining hollow electrodes

Powder type	Chemical composition, %											
	Fe	Co	C	Cu	Al	Cr	Mn	B	Si	Sn	Zn	Ti
I	balance	0.012	0.026	0.38	0.082	0.92	1.20	1.12	2.00	0.034	0.042	<0.005
II	balance	0.018	0.65	0.09	<0.005	11.53	0.98	2.09	2.04	<0.005	0.016	0.012
III	balance	0.017	0.87	0.06	0.020	15.80	1.86	2.66	3.90	<0.005	0.016	0.040

The powder particles morphology was investigated by means of a CITOVAL stereomicroscope produced by Carl Zeiss Jena.

As seen in Fig. 1 the powder consists of mate particles with various shapes, from angular to irregular polyhedral ones. The particles have a biphasic structure, consisting of carbide hard grains and a soft matrix of nickel or chromium.

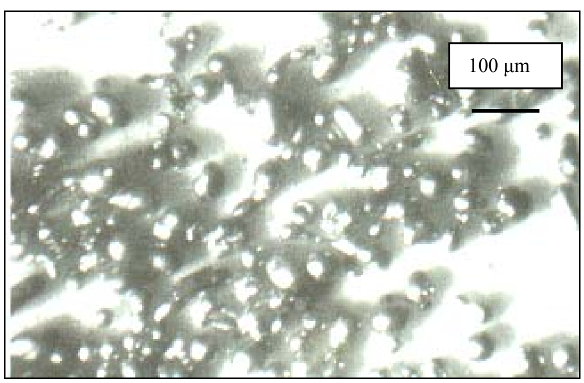

Fig. 1 Optical micrograph of FeCrSiNiMnC powder

Fig. 2 puts in evidence the spheroidal shape of some particles. From place to place particle satellites appear as they result of the specific atomisation phenomena through the two fluids method. As clearly seen in Fig.1, very often the particles have a dendritic shape specific for a cast structure [4].

Thus, at micro level the powder is heterogeneous from the structure point of view. The atypical structures for a metallic material solidification may be ascribed to the phenomenon that interfere with the water stream (possible segregation appeared in anticrucible pot, the place where the powder particle solidifies in comparison with the disintegration point of atomised metallic stream, a.s.o.).

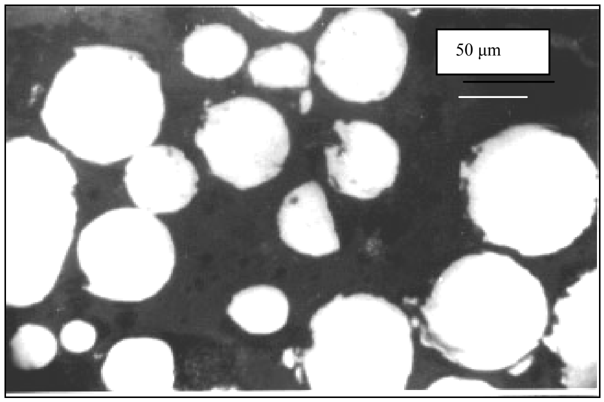

Fig. 2 Optical microstructure of FeCrSiNiMnC powder

In present atypical structures it can be observed dendrite agglomerations of small sizes in the grains central zone. This agglomeration of alloying elements in the central zone appeared due to some possible diffusion phenomena and dendrites accelerated growing in the first part of solidification process, on the basis of unhomogeneous repartition in liquid metallic particle, of nucleation and growing centers.

The grain size distribution of the powders has been investigated through sieving analysis (Romanian Standard 8431-79) using a standardized sieves set, laid on an electromagnetic vibrator. After weighting the grading fractions remained on each sieve and on the collector plate, the percentage mass of each fraction was calculated. Grading spectrum and the average grain size for the tree types of investigated powders are presented in Table 2.

Table 2

Grading repartition of obtained powders

Powder type	Grading reparation, %									$D_{mean,}$ [μm]
	+500 [μm]	+300 [μm]	+200 [μm]	+160 [μm]	+128 [μm]	+80 [μm]	+63 [μm]	+40 [μm]	-40 [μm]	
I	3.32	8.95	7.4	6.95	10.5	19.5	8.5	12.6	22.15	54.33
II	3.2	10.85	9.2	8.1	10.7	17.7	8.3	11.3	20.7	57.45
III	1.5	11	8.5	13	17	12	10.5	12.5	14	68.02

The calculated value of particle mean diameter was comprised between 54.33 μm for the first charge and 68.02 μm for the second charge.

The mean particle diameter D_{mean} was calculated using the following formula:

$$D_{mean} = 100/\Sigma(a_i/d_{i\ mean}) \text{ , [mm]} \quad (1)$$

where a_i represents the t grading fractions content, in %, and $d_{i\ mean}$ - grading fractions mean diameter.

After the powder was dried it was separated on sieves with 125 μm, respectively 45 μm dimensions. The result of this process will be the powder fraction that will be used in the next step of the flow sheet. [5]

In Fig. 3 are presented the particle size distribution for the obtained powders.

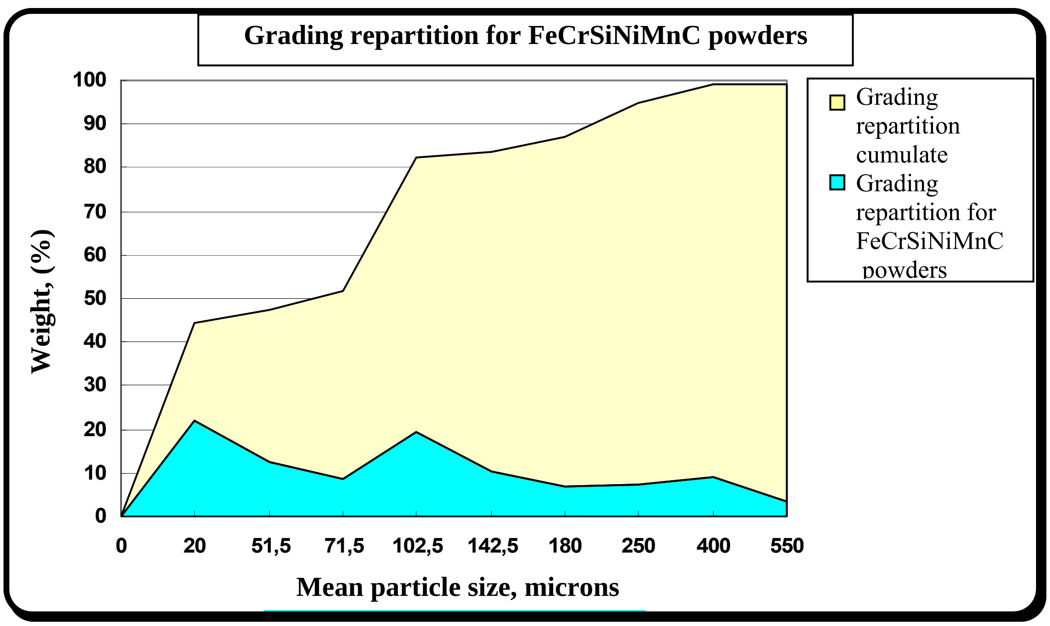

Fig. 3 Grading repartition for FeCrSiNiMnC powders

For the hollow formation a cold steel laminated belt, type A3K04M was used, with 15x0.5 mm and 20x0.5 mm dimensions, the obtained hollowed rods having 4.8 mm, respectively 6.4 mm. The hollow rod filling was carried out using a belt pocket, which permitted simultaneously two cores filling/dosage with different sensible grading classes [6].

The dosage belt is acted by a continuous current engine (Fronius type) and permit the belt continuous adjust, respectively the flow filling adjust. Also, with some vane valves mounted at the dosage bunker it is possible to fix the layer mixing thickness entrained by the belt.

The mean filling coefficients had values between 56-60 %. The hollow rods cutting at 350±5 mm length was made with a special cutting device.

3. Conclusions

A flow sheet has been established in order to obtain hollow electrodes from atomized powders.

The experiments for processing this type of powder were conducted in two steps:

1. in a first step the FeCrSi and NiCrSi master alloys have been obtained in the process through an aluminothermy procedure;
2. in the second step experiments for FeCrSiNiMnC powder processing using the atomization with high pressure water have been carried out.

The calculated value of mean particle diameter was between 54.33 μm for powder type I and 68.02 μm for powder type III.

The microscopic studies had permitted the atomized powder examination. Optical micrographs put in evidence the monophasic metallographic constituents such were: pure metal, solid solution, intermetallic compound, as well as the multiphase constituents: eutectics, eutectoids, disperse phase constituents formed through precipitation from supersaturated solid solution, a.s.o.

Further researches have in view the analysis of the physical properties, the influence of powder materials used upon the flow properties of obtained mixture powder.

R E F E R E N C E S

[1] Metal Handbook-Powder Sistems and Applications (p.569).
[2] Flame and Plasma-Spray Powders-prospect firma HCST
[3] Powder and particulate production of metalic alloys-N.J.Grant-Dep.of Materials Science and Engineering Massachusetts.Institute of Technology Cambridge.
[4] Advances and Applications in US Thermal Spray Technology (II The Market and R&D) - Ronald W.Smith -p.m.i, **vol 23**, nr.4,1991,(p.231).
[5] Metals Handbook, Ninth Edition,vol.7,Powder Metallurgy-American Society for Metals-Ohio, -1984.(p.25-51).
[6] IBID 10 (p.142).Production of Nickel Alloy Powders by Atomization-K.M.Kulkarni.